PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-196048
(43)Date of publication of application : 01.08.1995

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(51)Int.CI.
B62D 6/00
B62D 5/04
// B62D101:00
B62D119:00

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(21)Application number : 06-000936
(22)Date of filing : 10.01.1994
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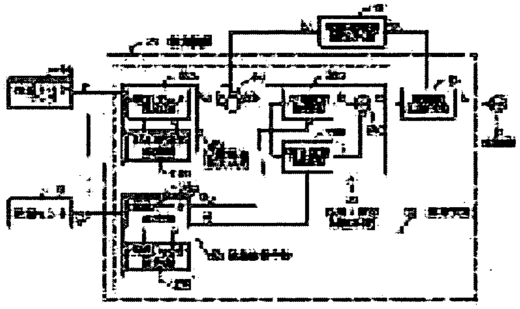
(54) ELECTRIC POWER STEERING DEVICE

(57)Abstract:

PURPOSE: To act large auxiliary steering force in low speed and act high-speed- response auxiliary steering force in high speed of a vehicle.

CONSTITUTION: An electric power steering device is provided with a control means 22 having a coefficient setting means 23 for changing proportional coefficient Kp and integral coefficient Ki of a proportional element control part 24A and an integral element control part 24B respectively in a proportional/ integral control means 24 based on speed signals V from a speed sensor 10.



LEGAL STATUS

[Date of request for examination]	27.10.2000
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3231932
[Date of registration]	14.09.2001
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	

[Date of extinction of right]

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[Claim(s)]

[Claim 1] Electromotive power-steering equipment characterized by having a coefficient setting means to change at least one side according to the vehicle speed signal from a vehicle speed sensor which detects the speed of vehicles to the aforementioned control means in the electromotive power-steering equipment equipped with the control means which consist of proportionality and an integral-control means characterized by providing the following among the coefficients of the proportional element of the aforementioned proportionality and integral-control means, and an integral element. The steering torque sensor which detects the steering torque of a steering system. The motor which makes the steering auxiliary force act on a steering system. The aforementioned motor is controlled based on the deflection of the target current from a target current setting means to determine the target current which drives the aforementioned motor based on the steering torque signal from the aforementioned steering torque sensor, and this target current setting means, and the motor current from a motor current detection means, and they are a proportional element and an integral element at least.

[Claim 2] The aforementioned coefficient setting means is electromotive power-steering equipment according to claim 1 characterized by making the coefficient of the aforementioned proportional element increase in connection with the increase in the vehicle speed signal from the aforementioned vehicle speed sensor.

[Claim 3] The aforementioned coefficient setting means is electromotive power-steering equipment according to claim 1 characterized by decreasing the coefficient of the aforementioned integral element in connection with the increase in the vehicle speed signal from the aforementioned vehicle speed sensor.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention is made to act on a steering system by making power of a motor into the steering auxiliary force, and relates to the electromotive power-steering equipment which aims at mitigation of a control force, especially the time of a low-speed run makes the big steering auxiliary force act, and is related with the electromotive power-steering equipment which makes the responsibility of the steering auxiliary force improve at the time of a high-speed run.

[0002]

[Description of the Prior Art] While setting up target current based on the vehicle speed which the steering torque which a steering torque detection means detects, and a vehicle speed detection means detect in conventional electromotive power-steering equipment and driving a motor What was constituted in the deflection of target current and the motor current which actually flows to a motor so that a phase lag row might be compensated for deflection through proportionality and an integral-control means (PI control), or a proportional-plus-integral-plus-derivative-control means (PID control) is known.

[0003] The important section block block diagram of the control unit of conventional electromotive power-steering equipment is shown in drawing 3 at the conventional electromotive power-steering equipment whole block diagram, and drawing 4 . In drawing 3 electromotive power-steering equipment 1 The rack & pinion mechanism 5 which consists of a steering wheel 2, the steering shaft 3, hypoid gears 4, pinion 5a, rack shaft 5b, etc., a tie rod 6, the front wheel 7 of a steering wheel, the motor 8 that generates the steering auxiliary force, and the steering torque which acts on a steering wheel 2 are detected. The steering torque sensor 10 and the vehicle speed which output the steering torque signal T changed into the electrical signal corresponding to steering torque are detected. It has the control unit 12 which controls the drive of a motor 8 based on the vehicle speed sensor 11, the steering torque signal T, and vehicle speed signal V which output the vehicle speed signal V changed into the electrical signal corresponding to the vehicle speed.

[0004] If a steering wheel 2 is steered, the steering torque sensor 10 prepared in the steering shaft 3 will change steering torque into the electrical signal which detects and corresponds, and will send the steering torque signal T to a control unit 12. Moreover, the turning effort of pinion 5a is changed into the rotation added to the steering shaft 3 by the rectilinear motion of the shaft orientations of rack shaft 5b through the rack & pinion mechanism 5, and it changes steering of a front wheel 7 through a tie rod 6.

[0005] On the other hand, the vehicle speed sensor 11 changes the vehicle speed of vehicles into the electrical signal which detects and corresponds, and sends a vehicle speed signal V to a control unit 12. A control unit 12 generates the motor current IM which drives a motor 8 based on the steering torque signal T and a vehicle speed signal V, and a motor 8 makes the steering auxiliary force act on a steering system through hypoid gears 4, and it is constituted so that mitigation of the control force applied to a steering wheel 2 may be aimed at.

[0006] In drawing 4 the control unit 12 of electromotive power-steering equipment 1 The steering torque signal T from the steering torque sensor 10 And the target current setting means 13 and deflection deltaIM of target current IMS and motor current IM which change the vehicle speed signal V shown in drawing 6 based on the vehicle speed signal V from the vehicle speed sensor 11 into the target current IMS of the steering (torque T) / target current (IMS) property (table 1) made into the parameter It has the subtractor 14 to calculate, proportionality / integration (PI) control means 15 which generate proportionality and the current control signal IO which carries out an integral compensation and drives the motor driving means 16 for deflection deltaIM, and the motor driving means 16 which generate motor current IM based on the current control signal IO, and drive a motor 8.

[0007] Proportionality and the integral-control means 15 are equipped with a proportional element (P:proportion) and an integral element (I:integral) in parallel, and Gain G and the phase angle theta of the transfer function F (jomega) are expressed with the Bode diagram shown in drawing 5 .

[0008] In drawing 5 , although ****** (theta=-90 degree) ** has the angular frequency omega corresponding to steering rotational speed in a low field, Gain G (20logG) can improve sharply, and on the other hand, although Gain G (20logG) has low angular frequency omega in a high field, it is known that phase lag can improve sharply.

[0009]

[Problem(s) to be Solved by the Invention] Although as for conventional electromotive power-steering equipment phase lag has about 90 gain G (20logG) in the field (range A) of the big angular frequency omega so that clearly from the Bode diagram shown in drawing 5 Since motor current IM is large when this has large target current IMS of the table 1 of drawing 6 like [at the time of a low-speed run] (V:L), the conditions shown in several 2 can express the real assistant torque Ta of a motor 8 expressed with several 1 by several 3. However, as for the moment of inertia of a motor, and CM, the coefficient of viscosity of a motor and f express the friction of a motor, and steering angle-of-rotation acceleration and thetaM' express [the torque constant and jump on minus whose kT is a motor] the steering angular rate of rotation thetaM".

[0010]

[Equation 1]

$$Ta = k_T * I_M - J_M * \theta_M'' - C_M * \theta_M' \pm f$$

[0011]

[Equation 2]

$$k_T * I_M >> J_M * \theta_M'' + C_M * \theta_M' \pm f$$

[0012]

[Equation 3]

$$Ta \fallingdotseq k_T * I_M$$

[0013] Thus, it is at the low-speed run time, and when target current IMS is large and motor current IM has it, even if the phase contrast of 90 degrees arises in deflection deltaIM of target current IMS and motor current IM, a bad influence does not do to a steering feeling. [large]

[0014] Since motor current IM is small at the time of a high-speed run when the target current IMS of the table 1 of drawing 6 [like] is small (V:H), it becomes impossible on the other hand, to disregard the influence of the several 2 right-hand side. Therefore, where the phase contrast of 90 degrees is produced in deflection deltaIM of target current IMS and motor current IM, when the current control signal IO is generated, the phase contrast of the several 2 right-hand side is added, and the technical problem which causes the fall of a steering feeling occurs.

[0015] While it was made in order that this invention might solve such a technical problem, and the purpose makes the steering auxiliary force at the time of a low-speed run increase, it is in offering the electromotive power-steering equipment which raises the responsibility of the steering auxiliary force at the time of a high-speed run.

[0016]

[Means for Solving the Problem] The electromotive power-steering equipment applied to this invention in order to solve the aforementioned technical problem is characterized by equipping control means with a coefficient setting means to change at least one side according to the vehicle speed signal from a vehicle speed sensor which detects the speed of vehicles among the coefficients of the proportional element of proportionality and an integral-control means, and an integral element.

[0017] Moreover, the coefficient setting means of control means is characterized by making the coefficient of a proportional element increase with the increase in the vehicle speed signal from the aforementioned vehicle speed sensor.

[0018] Furthermore, the coefficient setting means of control means is characterized by decreasing the coefficient of an integral element with the increase in the vehicle speed signal from a vehicle speed sensor.

[0019]

[Function] Since the electromotive power-steering equipment concerning this invention equipped control means with a coefficient setting means to change the coefficient of the proportional element of proportionality and an integral-control means, and an integral element according to the vehicle speed, it can make the steering auxiliary force at the time of a low-speed run able to increase, and can raise the responsibility of the steering auxiliary force at the time of a high-speed run.

[0020] Moreover, since the electromotive power-steering equipment concerning this invention equipped control means with a coefficient setting means to decrease the coefficient of an increase or an integral element in the coefficient of the proportional element of proportionality and an integral-control means, with the increase in the vehicle speed, it can make the steering auxiliary force at the time of a low-speed run able to increase, and can raise the responsibility of the steering auxiliary force at the time of a high-speed run.

[0021]

[Example] Hereafter, the example of this invention is explained based on an accompanying drawing. Drawing 1 is the important section block block diagram of the control unit of the electromotive power-steering equipment concerning this invention. In drawing 1 , a control unit 21 is constituted from control means 22 and motor driving means 16, and control means 22 are equipped with the target current setting means 13, a subtractor 14, the coefficient setting means 23, and proportionality and an integral-control means 24. In addition, the motor current detection means 17 detects the current IMD corresponding to the motor current IM which drives a motor 8, and changes and outputs it to the motor current IMO suitable for control.

[0022] Based on the vehicle speed signal V which the steering torque signal T and the vehicle-speed sensor 11 which were equipped with current data selection section 13A and target current-value storage section 13B, and the steering torque sensor 10 detected, and were changed into the electrical signal detected, and was changed into the electrical signal, the target current setting means 13 selects the target current value IMS which current data selection section 13A has memorized to target current-value storage section 13B beforehand, and outputs the target current signal IMS to a subtractor 14. Target current-value storage section 13B is constituted from memory, such as ROM, and memorizes the target current value IMS which made the parameter the vehicle speed signal V corresponding to the steering torque T as shown in the table 1 beforehand shown in drawing 6 .

[0023] The coefficient setting means 23 selects the proportionality coefficient Kp and the integration coefficient Ki of proportionality and the integral-control means 24 which coefficient data selection section 23A has memorized to coefficient storage section 23B beforehand, provides proportionality and the integral-control means 24 with them, and changes the value of a proportionality coefficient Kp and the integration coefficient Ki based on the vehicle speed signal V which was equipped with coefficient data selection section 23A and coefficient storage section 23B, and the vehicle-speed sensor 11 detected, and was changed into the electrical signal. Coefficient storage section 23B is constituted from memory, such as ROM, and memorizes the proportionality coefficient Kp and the integration coefficient Ki corresponding to the vehicle speed signal V as shown in the table 2 beforehand shown in drawing 7 . In addition, as shown in drawing 7 , a proportionality coefficient Kp is set up so that it may increase with the increase in a vehicle speed signal V, and it sets up the integration coefficient Ki so that it may decrease with the increase in a vehicle speed signal V.

[0024] Proportionality and the integral-control means 24 are equipped with proportional-element control-section 24A, integral-element control-section 24B, and adder 24C, gives an integration operator to a proportionality operation row, respectively, and outputs the current control signal IO adding the result of an operation to deflection deltaIM of the target current value IMS and motor current IMO supplied from a subtractor 14 at the motor driving means 16. Proportional-element control-section 24A and integral-element control-section 24B are equipped with the coefficient setting section which is not illustrated, respectively, and set up the value of the proportionality coefficient Kp offered from the coefficient setting means 23, and the integration coefficient Ki.

[0025] Generally the transfer function FPI (jomega) of proportionality and the integral-control means 24 is expressed with several 4 using a proportionality coefficient Kp and the integration coefficient Ki.

[0026]

[Equation 4]

$$
\begin{aligned}
F_{PI}(j\omega) &= Kp + Ki / j\omega \\
&= Kp\,(1 + Ki / j\omega Kp) \\
&= Kp\,(1 + 1 / j\omega Ti) \\
\text{ただし、} Ti &= Kp / Ki
\end{aligned}
$$

[0027] A phase angle theta and gain several 4 to 20 log|GPI(jomega) | are computed, and a-five number and several 6 are obtained, respectively.

[0028]

[Equation 5]

$$\theta = \tan^{-1}(-1/\omega Ti)$$

[0029]

[Equation 6]

$$
\begin{aligned}
20\log|G_{PI}(j\omega)| &= 20\log(Kp) \\
&\quad + 10\log\{1 + 1/(\omega Ti)^2\}
\end{aligned}
$$

[0030] The Bode diagram of proportionality / integration means which made the vehicle speed V the parameter at drawing 2 is shown. In drawing 2 , a phase theta becomes -45 degrees with the break-point angular frequency used as omega=omega S=1 / Ti (=Ki/Kp), and, on the other hand, gain 20 log|GPI(jomega) | becomes 20log(Kp) using an asymptote. (In practice, gain of an asymptote 3dB rise)

Although the angular frequency omega showing steering rotational speed is generally small when the vehicle speed V is a low speed, and the vehicle speed V is large when high-speed, it is in the range of 1-10 [rad/s] shown in the range A of drawing 2 . Following on angular frequency omega becoming larger (omega>=omegaS) than break-point angular-frequency omegaS, a phase theta approaches 0 times and gain 20 log|GPI(jomega) | maintains constant value 20log(Kp). moreover, the angular frequency omega -- a break-point angular-frequency omega left hand lay -- small (omega<omegaS) -- alike -- following -- theta-90 phases -- approaching -- gain 20 log|GPI(jomega) | -- constant value 20 -- along with the asymptote of 20logomega, it increases

from log (Kp)

[0031] Moreover, the phase at the time (V:M) of medium speed, gain characteristics (dashed line display), and the vehicle speed V show [the vehicle speed V] the phase and gain characteristics (alternate long and short dash line display) at the time (V:H) of high speed to drawing 2 on the basis of the phase and gain characteristics (solid line display) which the vehicle speed V made break-point angular-frequency omegaS=102[rad/s] in the time (V:L) of a low speed. Since it follows on increasing to high speed further, the vehicle speed V increases gradually medium speed and the proportionality coefficient Kp offered from the coefficient setting means 23 from a low speed and the integration coefficient Ki decreases gradually on the other hand Although break-point angular-frequency omegaS becomes a low value (10 [rad/s] for example, medium speed high speed below 1 [rad/s]) with the increase in the vehicle speed V and gain falls gradually, a phase improves sharply in the field of Range A.

[0032] In addition, if the vehicle speed V sets it as break-point angular-frequency omegaS=102[rad/s] (the same property as drawing 5) in the time (V:L) of a low speed, in order that medium speed and the gain which can be set at high speed may decrease, the target current IMS of the table 1 shown in drawing 6 memorized in the target current-value storage section 13 section of the target setting means 13 is increased at medium speed (V:M) and high speed (V:H), and you may constitute so that a decrement may be compensated.

[0033] Thus, since it had a coefficient setting means 23 to have increased the proportionality coefficient Kp of proportionality and the integral-control means 24 to control means 22 corresponding to the increase in a vehicle speed signal V, and to decrease the integration coefficient Ki, if gain is high and high-speed at a low speed, the current control signal IO with little phase contrast can be supplied to the motor driving means 16. The motor driving means 16 supply motor current IM based on the current control signal IO, drive a motor 8, when the vehicle speed is a low speed, they make the big steering auxiliary force act on a steering system, and when the vehicle speed is high-speed, they can make the steering auxiliary force in which a response is quick act on a steering system.

[0034]

[Effect of the Invention] Since it established a coefficient setting means changed the proportionality coefficient and the integration coefficient of proportionality and an integral-control means to control means corresponding to the increase in the vehicle speed, the electromotive power-steering equipment applied to this invention as explained above makes the big steering auxiliary force at the time of a low-speed run act on a steering system, and phase lag can be improved at the time of a high-speed run, and it can make the steering auxiliary force in_which of a response is quick act on a steering system.

[0035] Therefore, the electromotive power-steering equipment with which a suitable steering feeling is obtained by the low-speed run row also to any of a high-speed run can be offered. In addition, in an example, although proportionality and the integral-control means (PI control) were explained, this invention cannot be overemphasized by that it is applicable also to a proportional-plus-integral-plus-derivative-control means (PID control). Moreover, when applying to a proportional-plus-integral-plus-derivative-control means (PID control), it is also distinct by changing a derivative element corresponding to the vehicle speed that a steering performance can be raised further.

[Brief Description of the Drawings]

[Drawing 1] The important section block block diagram of the control unit of the electromotive power-steering equipment concerning this invention

[Drawing 2] The Bode diagram of proportionality / integration means which made the vehicle speed V the parameter

[Drawing 3] The conventional electromotive power-steering equipment whole block diagram

[Drawing 4] The important section block block diagram of the control unit of conventional electromotive power-steering equipment

[Drawing 5] Bode diagram

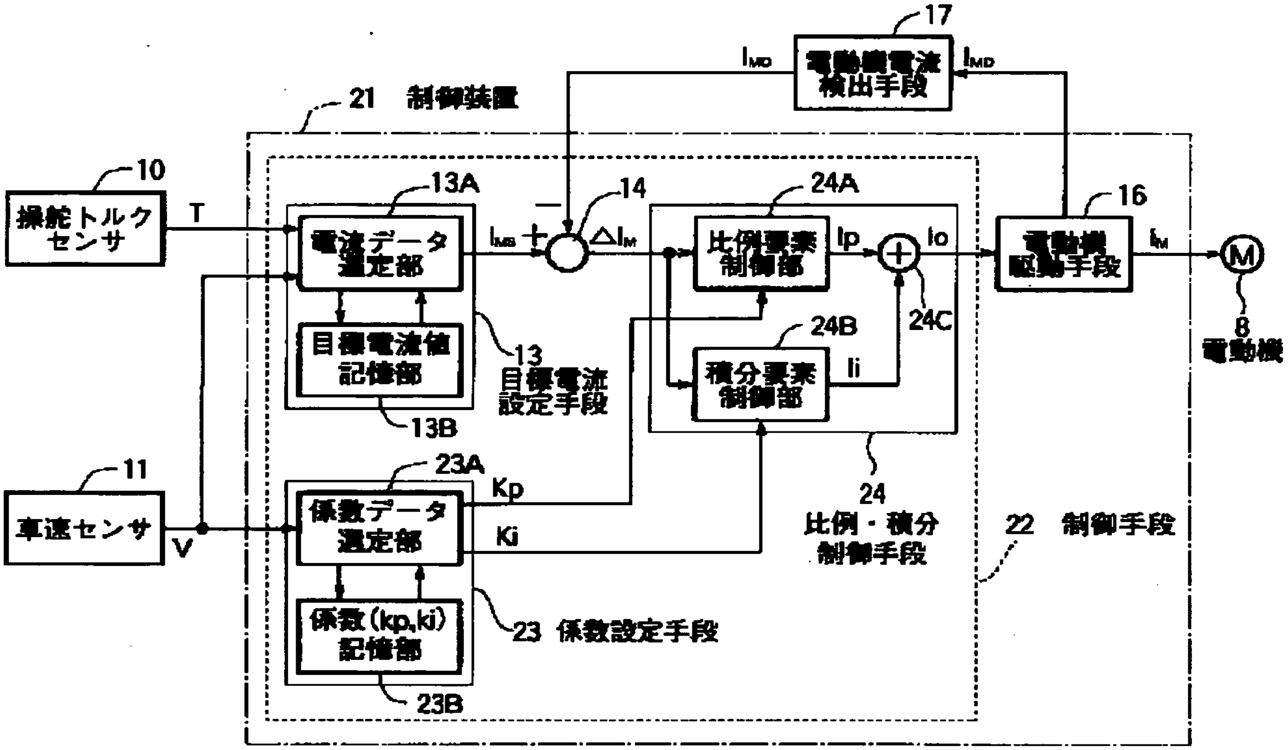
[Drawing 6] The steering (torque T) / target current (IMS) property which made the vehicle speed V the parameter (table 1)

[Drawing 7] The proportionality coefficient Kp and the integration coefficient Ki (table 2) corresponding to the vehicle speed V

[Description of Notations]

1 [-- Steering shaft,] -- Electromotive power-steering equipment, 2 -- A steering wheel, 3 4 [-- Pinion,] -- Hypoid gears, 5 -- A rack & pinion mechanism, 5a 5b [-- A front wheel, 8 / -- A motor, 10 / -- Steering torque sensor,] -- A rack shaft, 6 -- A tie rod, 7 11 [-- Target current setting means,] -- 12 A vehicle speed sensor, 21 -- A control unit, 13 13a [-- Subtractor,] -- The current data setting section, 13b -- The target current-value storage section, 14 15 24 [-- Motor current detection means,] -- Proportionality and an integral-control means, 16 -- Motor driving means, 17 22 [-- Coefficient data selection section,] -- Control means, 23 -- A coefficient setting means, 23A 23B [-- An integral-element control section, 24C / -- An adder, IMS / -- Target current, IMO / -- Motor current, Kp / -- A proportionality coefficient, Ki / -- An integration coefficient, T / -- A steering torque signal, V / -- Vehicle speed signal.] -- The coefficient storage section, 24A -- A proportional-element control section, 24B

[Drawing 1]


17
I_{MD}
電動機電流
検出手段
I_{MD}
21 制御装置
10
操舵トルク
センサ
T
13A
電流データ
選定部
目標電流値
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Ip
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24C
24B
積分要素
制御部
Ii
16
電動機
駆動手段
I_M
M
8
電動機
11
車速センサ
V
23A
係数データ
選定部
Kp
Ki
係数(kp,ki)
記憶部
23B
23 係数設定手段
24
比例・積分
制御手段
22 制御手段